# THINGS
## of science

# HOLIDAY ORNAMENTS

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# HOLIDAY ORNAMENTS

Myths and legends surround the origin of using evergreens during the Christmas season. Some historians trace the custom back to the pre-Christian era, to the ancient Egyptians or to the Romans who celebrated the winter solstice with garlands of evergreens. Others attribute the tradition to medieval Christians and to their use of branches of evergreens in their churches and as a part of their Christian festivals.

The idea of decorating the tree to add to the festivity of Christmas may be an outgrowth of the custom of early forest peoples who placed fruits and other gifts on trees as offerings to their deities.

The Christmas tree tradition, therefore, seems to have gradually developed, influenced by both pagan and religious ideas. Whatever its origin, the custom of bringing a tree into the house and decorating it at Christmastime grew slowly through the ages. The decorated tree as we know it today is believed to have originated in Germany during the 16th century.

It was not until the middle of the 19th century that the custom took hold in the United States. In 1856, the Christmas tree was introduced into the White House

for the first time by President Franklin Pierce.

The modern Christmas tree with its strings of flashing electric lights and factory-made ornaments bears little resemblance to the simpler trees of yesteryear. Early American Christmas trees were trimmed with fruits, nuts, popcorn strings, colored paper, cranberries and tufts of cotton to represent snow.

Handmade ornaments today have been largely replaced by the store-bought variety. But it is still a challenge and fun to make various objects to hang on the tree. By applying some of our scientific knowledge, we can create some interesting and unusual "scientific" tree ornaments.

First examine your materials.

STYROFOAM BALLS—Six white balls.

CLAY—Green; 1 x ¾ x 1½ inches.

MICA—White crystals in polyethylene bag.

ALUMINUM FOIL—Three sheets of different gauges—.005 gauge, 3 x 3 inches in size, the thickest; .003 gauge, 3 x 3 inches, the next in thickness; .001 gauge, 3 x 5 inches, the thinnest sheet.

COLORED PAPER—Two strips, ¾ x 8 inches.

WIRE—Flexible wire; 5 inches long.

## MICA SNOW

**Experiment 1.** Look at the mica flakes in the polyethylene bag and notice their luster and how they glisten as they reflect the light.

Shake some of the flakes into the palm of your hand and look at them through a magnifying glass. Notice that they are made up of tiny flat glasslike sheets. Are any of the larger pieces composed of more than one layer of mica? If so, peel off the thin flat layers with your fingernail. Notice how easily they separate. Mica is characterized by its perfect cleavage into sheets.

**Experiment 2.** Look again carefully at the mica with your magnifying glass. Observe that the surface in many of the pieces is irregular or curved and that they are not all lying on the same plane as they rest on your palm. As a result, the light striking the flakes is reflected in various directions. Since you can see only the light rays that happen to reach your eyes, the slightest movement of your palm causes the light reflected from the tiny flakes to appear or disappear. This sparkling effect of mica makes it useful for decorative purposes.

The whitest grade of mica available is always used for Christmas snow. Chemi-

cally mica is a complex silicate compound and does not burn. Some of the mica destined to ornament Christmas trees is mined in South Dakota, then ground and screened to the proper size. The rest is imported, mostly from India.

Mica has many uses other than as Christmas snow. A coarse grade of mica similar to your specimen, but not as white, is used in the electrical industry for condensers and as insulating material. Finely ground mica is applied to asphalt shingles, roll roofing and insulated wire and cable to prevent sticking. In many types of plastic, it serves as a filler to improve electrical insulation.

You can decorate the ornaments you make with your mica flakes or sprinkle them here and there on your tree.

When using the mica to enhance your ornaments, spread it on a large sheet of clean paper. Then apply a little glue to the spots on the ornament you wish to decorate. Press the spots down on the mica lightly. This will prevent the mica from scattering.

## MOLECULAR MODELS

Models of molecular structures are often used to help visualize the spatial relationships of atoms in chemical compounds.

When atoms combine with other atoms to form compounds, they arrange themselves in a particular way in relation to each other, making interesting patterns in space. We can make use of some of them to create unusual tree ornaments.

With the six styrofoam balls in your unit, you can make one or more ornaments. After constructing the various molecules in the following experiments, decide which ones you wish to keep to decorate your tree. Then glue the parts together with strong adhesive such as epoxy glue. Insert a straight pin in the model at the top and hang it with a piece of thread. The styrofoam balls may be colored with crayon or paint.

If you wish to coat any of the styrofoam balls with mica, first spread the mica on a sheet of paper. Then cover the styrofoam ball with a thin film of glue and roll it in the mica.

**Experiment 3.** Let us start with a model of the water molecule. You are familiar with the chemical formula for water, $H_2O$. This is the empirical formula of water. An empirical formula tells you the number and kinds of elements that compose a compound. From the formula $H_2O$, you can tell that a water molecule contains two atoms of hydrogen and one

atom of oxygen. But that is all.

The formula of water may also be written H-O-H. This formula is called a structural formula. It gives you an idea of the structure of water in two dimensions.

A structural formula, however, does not let you know how the atoms are arranged in space. For this you need a three-dimensional picture or a model.

To make a model of a molecule of water, break off two pieces from the clay in your unit and form them into balls about ⅜-inch in diameter to represent hydrogen atoms. Use one of your styrofoam balls for the oxygen atom.

When two hydrogen atoms combine with an oxygen atom to form water, they are linked to the oxygen atom at an angle of about 104.5 degrees from each other.

Place one of the clay balls at any point on the styrofoam ball. Apply a little pressure to make it stick. Place the second "hydrogen atom" 104.5 degrees from the

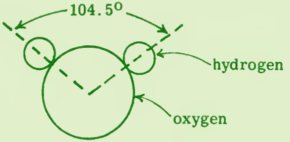



**Fig. 1**

other. Use a protractor to measure the angle (Fig. 1).

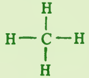
Now you have an idea of the spatial relationship of the atoms in a molecule of water, and a drop of water to hang from your tree.

Models are especially useful in the study of carbon compounds in organic chemistry, many of which are extremely complex.

**Experiment 4.** We can construct models of some of the simpler carbon compounds for ornaments.

Carbon has the ability to combine with four other atoms. When four atoms combine with a carbon atom, the angle between any two of the atoms is around 109.5 degrees.

One of the simplest carbon compounds is methane having the empirical formula $CH_4$ and structural formula



Make four small balls from your clay and place them 109.5 degrees from each other on one of the styrofoam balls. You now have a model of a molecule of methane, the main constituent of natural gas.

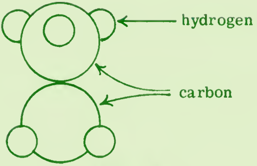



**Fig. 2**

Carbon compounds such as methane composed only of carbon and hydrogen atoms are known as hydrocarbons.

**Experiment 5.** Build another methane molecule. Remove one of the hydrogen atoms from the methane molecule. A methane molecule with one hydrogen atom missing is called a methyl radical. Since it has one hydrogen missing, it can combine with another radical. Remove a hydrogen from the other methane molecule and join the two radicals together at the point at which the hydrogen atoms were attached to the carbon atom (Fig. 2). The new compound is ethane.

Turn the carbon atoms so that one hydrogen will face forward as the nose. Make two black dots for eyes. Turn the other carbon atom so that one hydrogen atom faces directly backward as the tail and you have a little panda bear.

**Experiment 6.** If you remove a hydrogen from one of the carbon atoms in ethane and add another methyl radical,

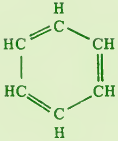


Fig. 3

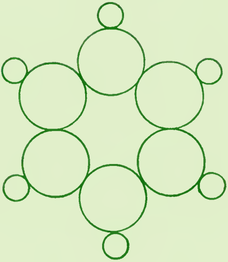


Fig. 4

you will have a third member of this series of hydrocarbons, propane. The symmetrical shape formed will also make an interesting ornament.

You can add methyl radicals successively to form a long chain. Hydrocarbons that form chains are called open chain or aliphatic compounds.

Hydrocarbons also form ring compounds, or aromatic compounds. Benzene is a common aromatic compound and is the first member of the series known as the benzene series.

The empirical formula of benzene is $C_6H_6$. Its structural formula (Fig. 3) shows why it is called a ring compound.

**Experiment 7.** Make a model of the benzene molecule (Fig. 4) and you will have a wreath. Use the six styrofoam balls

for the carbon atoms and clay for the hydrogen atoms.

**Experiment 8.** Under certain conditions, aliphatic compounds also react with other elements or groups of atoms. For example, the carboxyl radical, —COOH, combines with hydrocarbons to form organic acids.

If one of the hydrogens in methane is substituted by a carboxyl group, you will have acetic acid, $CH_3COOH$, a component of vinegar, having the structural formula

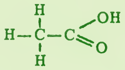


**Fig. 5**

Make a model of acetic acid (Fig. 6), using styrofoam balls for the carbon and

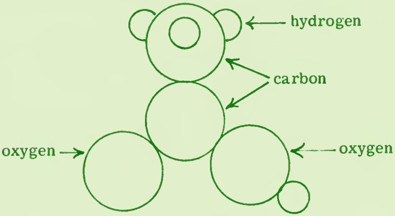



**Fig. 6**

oxygen atoms, coloring the oxygen atoms to distinguish them from the carbon atoms. Use clay again for the hydrogen atoms.

If you remove the hydrogen atom from the oxygen, you will have an acetate ion and a figure for your tree.

You may wish to make other molecular models. Elementary chemistry books containing illustrations of molecular models will be helpful.

## WHIRLING SPIRAL

In this next ornament you will apply both aerodynamics and optical illusion.

**Experiment 9.** Cut the 3 x 5-inch aluminum foil in half. Trace the spiral (Diagram 1, p. 27) on one-half of the foil, pressing down rather heavily to produce lines on the foil. With a dark colored broad felt marker about ³⁄₁₆-inch wide, trace over the lines on the aluminum foil. Cut along the lines and you will have a spiral bordered in color. Open the spiral up gently. Insert a fine thread through the dot at the top using a sewing needle (Fig. 7).

Hold the spiral over a lighted lamp or hot radiator and notice that it begins to whirl around. Why? The heat from the lamp causes the molecules of air to move about more rapidly and violently

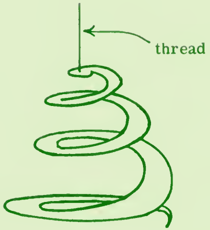



**Fig. 7**

and strike each other with greater force. The molecules as a result are pushed further apart and occupy a larger area, causing the air to become lighter and exert less downward pressure. The surrounding colder and heavier air moves down and under the warm air pushing it upward. As the warm air rises, it pushes against the spiral causing it to rotate. The cold air replaces the warm air and it too is warmed and moves up against the spiral. A continuous current is thus set up by a warm object. This type of air movement is called a convection current.

A room is heated or cooled by convection current. Convection currents are also largely responsible for the transfer of heat in the atmosphere.

**Experiment 10.** As the spiral turns clockwise, note that it seems to move

upward to the apex. If the direction of rotation is reversed, or is counterclockwise, the movement seems to be in the other direction, from apex to base. Although we know the spiral does not wind upward or downward, it appears to do so. If you stare at the spiral steadily as it is rotating the optical illusion is more pronounced.

Hang the spiral above one of your tree lights where it will be free to move unhindered. As the air above the lamp becomes warm, the spiral will begin to turn.

## DANCING DEER

All objects are held to the earth's surface by gravitational force. We are all aware that bodies fall because they are pulled toward the earth by the force of gravity. The magnitude of the force of gravity on a body is known as its weight.

There is a certain point in any object where its whole weight acts. This point is known as the center of gravity.

The center of gravity is an important factor in equilibrium. In general, an object will be in stable equilibrium if the center of gravity lies within the base of the object and is below the point of support. The lower the center of gravity of an object, the more stable it is. Also, if

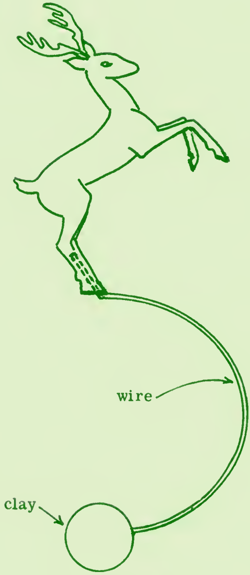



**Fig. 8**

the center of gravity is raised when an object is tilted, it is in stable equilibrium.

**Experiment 11.** Applying this knowledge of the center of gravity, we can make a deer dance up and down on its hind legs on a branch of a tree without losing its balance.

Trace the diagram of the reindeer (Dia-

gram 2, p. 27) onto the heavier 3 x 3-inch aluminum foil and cut it out. Cut out a second pair of hind legs only.

From your clay, make a ball about ¾ inches in diameter and insert one end of the 5-inch wire in your unit into it. Bend the other end of the wire slightly and attach it to the hind legs (Fig. 8). Glue the extra legs you cut out over the wire.

Curve the wire slightly forward away from the feet and downward so the clay ball is below the hind feet of the deer (Fig. 8). Perch the deer on the edge of a table, adjusting the weight so that the deer will stand balanced on its hind legs. When you push its nose down, the deer will dance up and down. Now place it on a branch of your Christamas tree and let it dance there.

Does your ornament satisfy the conditions for stable equilibrium?

**Experiment 12.** Mobiles utilize center of gravity in their structures. With bits and pieces of the aluminum foil left over after you have made all the other ornaments, you can construct tiny mobiles using a variety of geometric figures. Hang them from the tips of the branches.

The center of gravity of any flat object can be readily found by suspending it

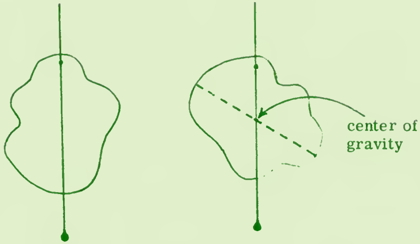



**Fig. 9**

from two different points successively. The point at which plumb lines suspended from these points intersect is the center of gravity (Fig. 9).

You can make a plumb line by simply attaching a small weight such as a paper clip or needle to a length of thread.

Find the center of gravity of a flat irregular shape by using the method described above. If the object is then suspended by a thread through the center of gravity, it will hang perfectly horizontally.

Use your imagination and make other movable ornaments for your tree.

## HEXAFLEXAGON

**Experiment 13.** Cut a strip of paper one inch wide and ten inches long from

any paper you may have on hand. Make a dot about ¼-inch from each end of the strip on the same side. Give one end a half turn and place one dot directly on the other and paste the edges together. You have a circular strip with a twist in it. This is known as a Moebius strip.

With a pencil draw a continuous line down the center of the strip along its entire length. You will come back to your starting point without crossing an edge. Cut the strip along the line you have drawn all the way around and you will have a surprise.

The Moebius strip has other unexpected characteristics that can be adapted for making tree ornaments.

**Experiment 14.** Cut the 2½ x 3-inch remaining half of the thin aluminum foil into ¼ x 3-inch strips. Take one of the strips and make a Moebius strip pasting the ends together securely. Flatten it and you will have a triangle (Fig. 10).

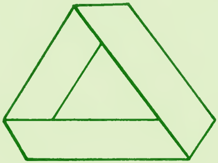


**Fig. 10**

Color several of the strips on one side with a felt marker. Use various colors. Insert one end of one of the colored strips through the center of the triangle you just made and paste the ends of this strip together with a twist into another Moebius strip and flatten it into a triangle. What happens to the colored side? Can you refold the triangle and make a different arrangement of colors? Insert the next strip into the second triangle and make another Moebius strip, flattening this into a triangle also. Repeat this with all the other strips of the foil and you will have a colorful chain of triangles for your tree. Or you can link the triangles to form different geometric patterns.

**Experiment 15.** Paste the two colored strips of paper in your unit together along the length back to back, keeping the colored surfaces on the outside. Allow the glue to dry completely.

With this strip we shall make a hexaflexagon, another variation of the Moebius strip.

Fold one edge in half for about ¾ inch (Fig. 11a) and crease. Then unfold it.

Fold B to the crease. Crease well along the fold AC (Fig. 11b).

Take corner A and fold it along CD (Fig. 11b) so that AC lies accurately

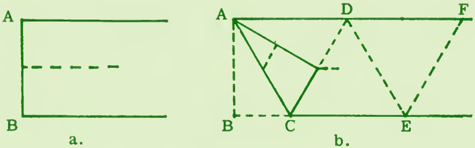



**Fig. 11**

on the lower edge of the strip at CE. Crease the fold CD well. Triangle CDA will be an equilateral triangle.

Now take corner C and fold it forward along line DE. Fold CD will meet the upper edge, DF, forming another triangle. Continue folding back and forth until a series of 12 equilateral triangles is formed. It is very important that in all the folds, the corners and edges are accurately matched.

Cut off the first two triangles to get rid of the lengthwise crease which served merely as a guide.

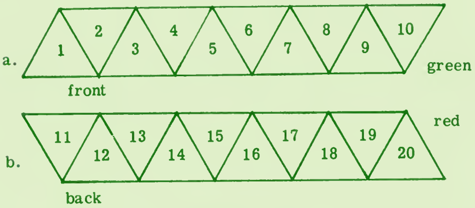



**Fig. 12**

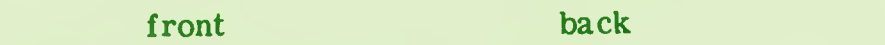
You should have 10 equilateral triangles. Lay the strip flat and label the triangles as shown in Fig. 12a. Mark them lightly in pencil so they can be easily erased.

Turn the strip over and mark it as shown in Fig. 12b. Be sure 11 is behind 1.

To make the hexaflexagon, fold triangle 1 over triangle 2. Then fold triangle 15 over triangle 14 and triangle 8 over triangle 7. If the hexagon is arranged as in Fig. 13, glue triangle 1 to triangle 10.

Your hexagon will open and give you six designs and three surfaces. Notice how the colors are arranged in your hexaflexagon. This pattern can be changed by flexing the hexaflexagon.

To flex the hexaflexagon (Fig. 13) with the left thumb and forefinger pinch the corner labeled AA, thus bringing the opposite triangles together. Push in the corner labeled BB. With the right thumb



(Darker lines indicate free edges.)

**Fig. 13**

pull out the corner labeled CC. The hexaflexagon will then open up flat from above and you will have a new color pattern. Handle the paper gently so that it will not tear and wrinkle. You may wish to practice on plain paper before you make your ornament.

Three designs will be formed on each side by successively flexing the hexaflexagon. When you decide which design you prefer, hang the hexaflexagon from your tree with a fine thread.

Hang this ornament away from the lights on your tree since it is made of paper and not fire resistant as are the aluminum foil, clay and styrofoam balls.

## STARS

A star is often placed at the top of the Christmas tree. You can make either a five-pointed star or a six-pointed star with the remaining 3 x 3-inch piece of aluminum foil (.003 gauge).

**Experiment 16.** A five-pointed star can be easily made with a ruler and protractor. We know that the sum of the angles of a circle is 360 degrees.

Make a dot on a sheet of plain paper thin enough so that you can trace the star on the aluminum foil. This point will

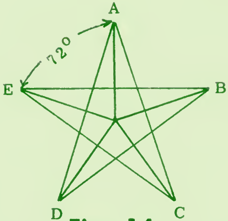



Fig. 14

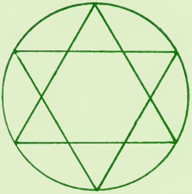


Fig. 15

be the center of the star. Mark off five equal angles of 72 degrees each around this point (one complete revolution around a point is equal to 360 degrees) making the sides of the angles 1½ inches long. Mark them A, B, C, D and E. Draw a line from A to C, B to D, C to E, D to A and E to B (Fig. 14), and you have your star. Trace this star onto your aluminum foil and cut it out for your tree.

**Experiment 17.** If you wish to make a six-pointed star instead, draw a circle three inches in diameter with a compass on a piece of lightweight paper suitable for tracing. The radius of a circle is one-sixth of the circumference of a circle. Measure the radius and mark off the circumference into six equal parts using your compass. Draw lines between alternating points to make the six-pointed star (Fig. 15). Trace the star on the aluminum foil and cut it out.

Many different species of evergreens are used as Christmas trees in America. For many years, the fir tree was the preferred evergreen but in recent years, it has been displaced in popularity by the pine.

Are you familiar with the different types of trees and can you identify them? If not, collect branches of various ones available in your neighborhood and let the following experiments help you recognize them.

**Experiment 18.** Most small trees do not bear fruit, cones or berries, which would be helpful in identification, but usually the needles (leaves) and their arrangement on the twig give sufficient information.

First note whether the leaves are needlelike or scalelike.

**Experiment 19.** If the leaves are needlelike, the tree may be a pine, spruce or fir.

Examine the needles. Are they in clusters of two or more? Or are they attached to the twig or branch singly?

If they are in clusters, the tree is a pine. If attached singly, it may be a fir or spruce.

Pines, spruces and firs bear cones and are known as conifers. You may find a

cone or two on some of your specimens.

**Experiment 20.** Look closely at the conifer needles. Are they medium long (1½ to 3 inches), stiff and twisted? Are the needles in bundles of two? If so, it is a Scotch pine.

Scotch pine holds ornaments well and is the most popular among the Christmas trees today.

**Experiment 21.** If the needles of the conifer are medium long, thin, and in bundles of five, then the tree is a white pine. Its leaves are blue-green in color and soft in texture.

**Experiment 22.** Now look at the conifers with single needles. Are the needles short—about ½ to 1¼ inches long—flat and dark green? These are characteristics of balsam fir. Examine the needles. They are usually rounded at the tips. Note the way in which the needles grow from the branches. They are arranged featherlike on tiny grayish, hairy twigs that grow at approximate right angles to the branches resembling crosses. Are there any cones present? Cones of the balsam fir are attached upright to the branch, purple in color and about two to three inches long.

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**Experiment 23.** You may come across a Douglas fir. Its needles are short-stalked, soft and pliable and about ¾ to 1¼ inches long. The blue-green needles are attached all around the twig. The cones of Douglas fir are light brown and hang down from the branches.

**Experiment 24.** If the single needles are curved, sharp-tipped and prickly, then the tree is most likely a spruce. The needles of spruce are short, about ½ to one inch long and stand out straight and stiff from the branch. They are four-angled and have a square or diamond-shaped cross section.

**Experiment 25.** If you have a redcedar in your collection, it will be easy to recognize. It has scalelike leaves and the fruit, if any are present, is berrylike. The scale-like leaves are very short, only about 1/16 of an inch long, and a dark blue-green. The slender twigs are leafy and may be rounded or four-angled.

Appreciation is expressed to Mr. Frank E. Jones, National Bureau of Standards, for reviewing this booklet.



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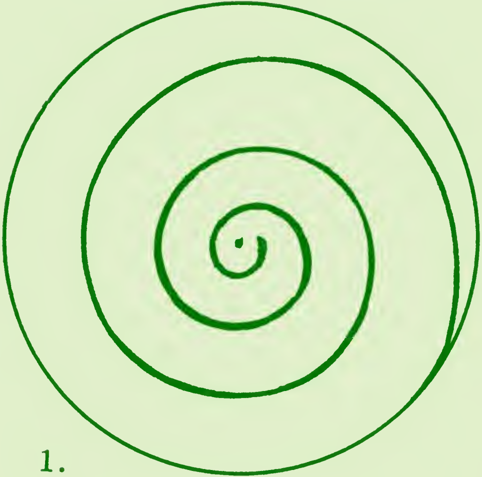

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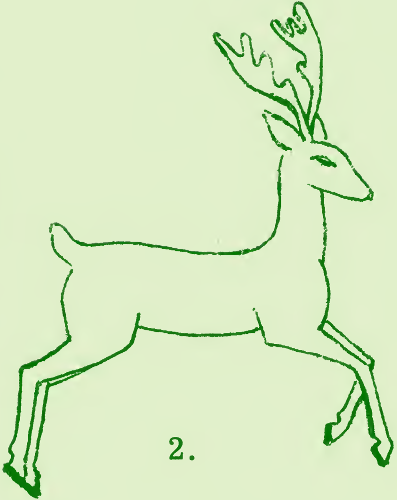

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